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1964

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Editor: M. J. Paul

Advertising: J. L. Hullett
T. W. Cole

Publications Staff: P. J. Farr
D. F. Feldman
C. R. Temby
D. V. Hambleton

1964

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U.E.C. COMMITTEE, 1963

Editorial

1964 has brought a new look, academically, to the Faculty of Engineering. For the first time the revised course has been introduced to the final year lectures, and at the end of the year the first class to experience this period of experimentation, will graduate. What was the reason for this change? How does the Faculty now stand with respect to other Faculties of Engineering in Australia? What will be the effect of this change on the graduate engineer and the community?

The new course was first implemented in 1961, along with the move to the new Engineering School. The change must primarily have been to make the fullest use of the new facilities available. Greater than this however, was the need to keep the course in line with latest developments and to build up an interest in research with a view to increasing the size and influence of the postgraduate school.

The laboratory space and lecturing facilities provided in the new Engineering School compare more than favourabily with any in Australia. The material being presented is placing the student in a better position to absorb the ever-expanding volume of technical literature being produced. Furthermore an introduction of the computer is providing a tool which must ultimately alleviate much of the more tedious calculation from the shoulders of the practicing engineer. By retaining the five year course, the Faculty has been given more time than in other Universities to place emphasis on the importance of the Engineer as part of a professional group and to broaden his outlook with regard to social, political, and economic factors, as demonstrated by the introduction of a course in Engineering in History.

If the new course has the desired effect, graduates in the years to come will be able more readily to push forward the theory and practice of engineering. The duty of the engineer is to serve the community; thus the community must ultimately benefit from any improvement in the efficiency of the profession. Furthermore in providing for the physical comfort of the community the status of the professional engineer in society will increase until it reaches its rightful position.

President's Report

Members of the University Engineers' Club,

On looking back at 1963, one overall impression stands out; the U.E.C. has finally changed over from the feelings of the old engineering school to the more up-to-date line of thought that goes with our new school. The present generation of members have had virtually no connection with Shenton House and the nostalgia that has gone with it. The club can now expect a rather startling increase in membership in the years to come and in using its now excellent environment, it should easily handle the extra activities involved.

The past history of the club must never be forgotten but it is essential for the club to adapt itself to the ever-changing conditions under which it exists. It is therefore essential, with the increasing numbers, for each member to take an added interest in club affairs—challenge club decisions if you feel inclined and do your best to keep the club alive and active.

1963 was a good year, remembering that the club's main objective is to foster fellowship among its members. Everyone worked hard at making the exhibition a success and the club activities were well supported and generally showed an improved standard. As the club grows the standard should continue to improve. Our socials, ball and dinner were enjoyed by all and the latter being in the jubilee year of the faculty, served as the club's recognition of the first fifty years of the University.

One disappointing aspect of the year was that in working to the new constitution, the Third Term General Meeting was held too close to the final exams to make a success of combining the meeting with a Smoke Social to follow. These were common in earlier years of the club and were most successful, and are well worth the club re-establishing them.

I wish to thank the Patron and Vice-Patrons for their support through the year and also I thank the club committee for their willing assistance. It is good to see some experienced faces on the incoming committee and I wish the club every success in the years to come.

R. A. PENBERTHY.

Noise and Parametric Amplifiers

by Trevor Cole

Noise

The object of nearly all radio transmission is to convey information from one place to another. The limits on possible information rates and path distances are set by noise, the random interference which adds to the signal and hence distorts it.

The first main group of noise sources consists of the Milky Way, distant galaxies, the Sun and the Earth. In general these sources of radio waves are said to produce galactic noise which is maximum at lower frequencies and decreases with frequency rise. As might be imagined, it would be very hard to remove these sources of noise although their effect can be minimised by pointing the antenna away from them.

A very close companion to galactic noise is man-made noise produced by car ignitions, electrotherapy equipment, electric welders and other such devices. This noise is especially apparent below 100 megacycles. As for galactic noise, the only real way to minimise man-made noise is to avoid it by such means as moving to the country.

The above two groups of noise sources are not the ones which are usually the controlling factor—receiver noise. In a radio receiver the limit to which weak signals can be amplified is set by the noise power introduced into the first few stages of the receiver. Since any noise power introduced is amplified along with the signal in succeeding stages, the first stage of amplification is an important one if low noise reception is to be achieved. But what are the sources of noise? The main ones are the active devices such as transistors and valves. Noise is introduced due to such properties as the randomness present in the device current. Valves and transistors become increasingly noisy as the frequency rises. Another element in the receiver to produce noise power is resistance in all its forms (including such things as radiation resistance of antennae). The resistance noise power is proportional to absolute temperature and hence could be reduced by cooling.

From the above it can be seen that the limit to a receiver's noise performance is set by the valves, transistors and resistors. The question has been asked, "Then why not remove these elements?" The parametric amplifier does just that.

Parametric Amplifiers

The parametric principle relies on the fact that an oscilalting system's energy may be increased by addition of energy at a frequency different to the fundamental frequency. The word "parametric" merely implies that this amplification is achieved by the alteration of a parameter.

Historical

Perhaps Faraday was one of the first to observe the phenomenon when, in 1831, he produced a ringing sound from a half full glass by rubbing his moistened finger around the brim of the glass. From this he concluded that the frequency of oscillation of the glass stem was twice that of the liquid.

In a similar way the energy of a pendulum may be increased if the support is vibrated vertically at twice the frequency of pendulum swing.

The electronic usage of this principle was perhaps first expounded by R. V. Hartley of Bell Telephone Laboratories in 1936, whereby amplification was to be achieved by variation of a reactive element in a resonant circuit. In 1948 van der Ziel propounded that parametric amplifiers would have a very low noise figure (the ratio of total output noise to noise due to input alone). This was due to the absence of valves with their shot effect and other effects and to the absence of resistance with its thermal agitation noise. The parametric amplifier is ideally reactive. Realisation of a practical amplifier had to wait until 1954 when Bell Telephone Laboratories produced the first low loss diode. Since then, development has been at a rate which is nothing short of fantastic.

Principles

The parameter which is altered is the capacitance of the resonant tuned circuit. To illustrate the effect, a parallel plate capacitor might be considered whose plate's spacing may be mechanically varied. If a sinusoidal source of voltage is applied, the voltage and charge on this capacitor will also vary sinusoidally. Now charge Q is related to voltage V on a capacitance C via Q equals CV. Thus, if when the charge on the capacitor is a maximum the plates are pulled apart, the charge remains constant, the capacitance is decreased and so

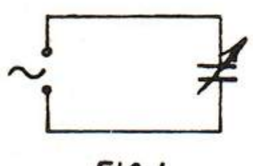


FIG. 1.

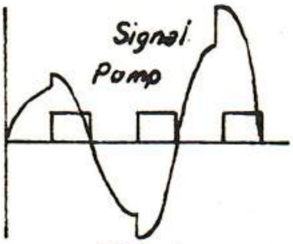


FIG. 2.

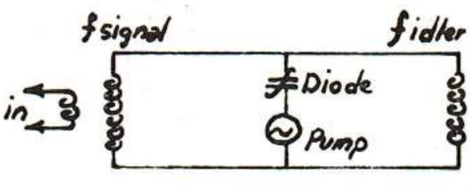


FIG. 3.

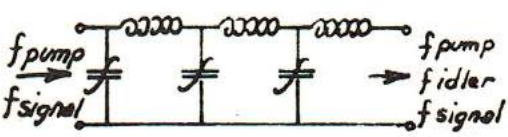


FIG. 4.

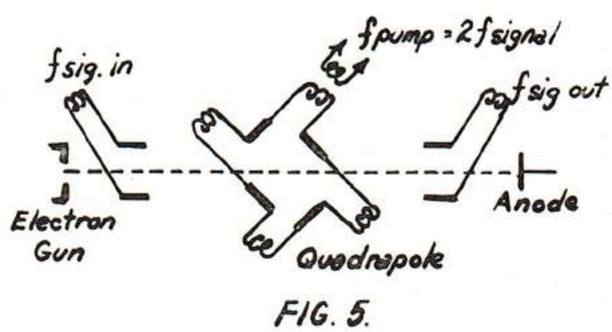


FIG. 5.

the voltage increases. The energy of the system is half QV and hence is increased (the energy is taken from the mechanical effort of pulling apart the plates). The plates may be returned to their original position with no energy transfer at the instant when there is zero charge on the plates. This is illustrated in the diagrams 1 and 2, and it can be seen that amplification is achieved when the plates are moved (i.e. "pumped") at exactly twice the signal frequency and at the exact phase position.

For the case where the pumping frequency is not exactly twice (or any exact multiple of) the signal frequency, there is alternate amplification and degeneration as the two pass through in-phase positions. That is, there is a beating effect between the signal frequency and the difference of the pump and signal frequencies. In practice it is quite difficult to have a pump which is phase locked to the signal and so the practical amplifier achieves amplification at any pump frequency by removing the beating difference frequency (idler frequency) in a tuned circuit, resonant at the idler frequency.

The resulting amplifier is characterised by a common input and output frequency, high gain at signal frequency, low noise and small bandwidth. Being a negative resistance type, it is not inherently stable.

The Variable Capacitor

A reverse biased semiconductor diode is used as the variable capacitance. The pumping of capacitance is achieved by alteration of the reverse bias which then alters the capacitance. As might be imagined, it is desirable that the diode losses at high frequencies be as small as possible. Silicon is the usual semiconductor because of its low saturation current, its ability to withstand higher temperatures without drift in

properties, and its more sharply defined properties. Since the diode becomes lossy and noisy when conducting, it is usual to provide some biasing to ensure operation is in the reverse biassed condition.

Amplifier Designs

The simplest design is that discussed above where there are signal and idler circuits in parallel, with the parametric diode being pumped by a pump oscillator. This is illustrated in Fig. 3.

The main disadvantage of this arrangement is that the output is directly coupled to the input so that noise feeding back from following stages can reach the input and be amplified. This can be overcome by the use of isolating devices such as the circulator.

A direct follow-on from this design are the up and down converters. Since the idler circuit energy is in direct relation to the signal, it is quite practical to take the output at the idler frequency which will, in general, be different to the signal frequency. By so doing, the output will be isolated from the input.

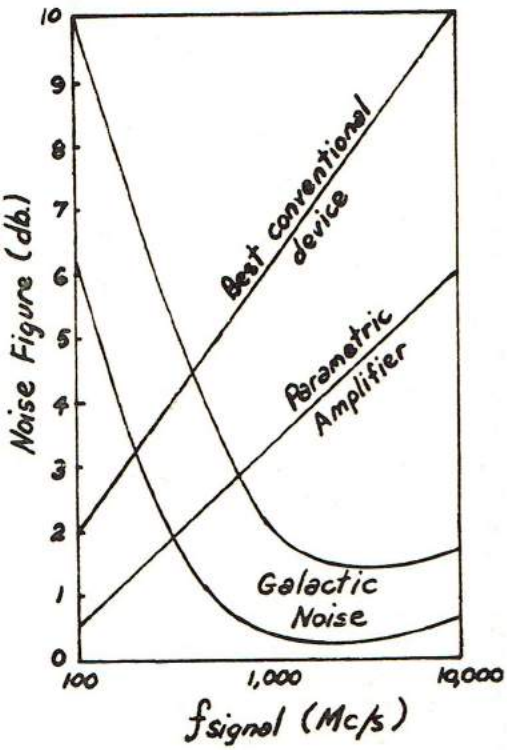
For the up-converter the output frequency is the sum of pump and signal frequencies. From the theory it can be shown that by so increasing the output frequency, the noise figure is improved. The low noise, inherent stability and circuit isolation of the up-converter are obtained at the expense of gain, and with the necessity of a good succeeding receiver at the higher frequency.

Following on these two basic types there have been many developments aimed at improving the bandwidth and stability problems. In the amplifiers described up till now, there have been narrow bandwidth tuned circuits contributing to the narrow bandwidth property of the device. P. K. Tien wrote on the conversion of a statically wideband device such as a low pass filter into a broadband parametric amplifier. The result is a travelling wave parametric amplifier with the capacitors of the low pass filter replaced by parametric diodes as shown in Fig. 4.

The Adler tube is an example where the parametric principle has been applied to a beam of electrons instead of a capacitance. In this tube, a narrow beam of electrons is spun at signal frequency before passing through a rotating electric field at pump frequency. The amplified output is then taken out by a pair of plates as shown in Fig. 5.

Applications

Parametric amplifiers are both expensive and rather specialised and hence their use must be restricted to cases where they would make a worthwhile contribution to system performance. For instance, there is no benefit to be had by increasing the receiver noise performance further than the limit set by terrestial or galactic noise. Hence for frequencies below approximately 100 Mcs the ordinary valve or transistor is sufficient. With increase in frequency above this an improvement can be had by using a parametric amplifier. This is revealed by an approximate plot of performance versus frequency as in Fig. 6.



Perhaps the improvement which can be attained by the use of such low noise receivers may be best shown by an example[1]. Pioneer

IV, the American moon rocket (fired 1959, March 3) had an 0.18 watt transmitter on 960 Mcs. The receiver had a noise figure of 5.7 (7.5 db) and hence a calculated maximum range of tracking of 1,150,000 miles. The use of a parametric amplifier of noise figure 1.35 (1.3 db) would have increased this range to 3,200,000 miles for the same antenna and bandwidth.

Summary

The parametric amplifier is a device which can vastly improve the performance of many communications systems. Little did Faraday realise in 1831 that such exotic devices would evolve around the principle he observed and measured.

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2. "Parametric Amplifiers", B. J. Simpson. Radiotronics, December, 1959.

☆ ☆ ☆

Prof. (after the final): "Well, what did you think of the course?"

Student: "I thought that it was all inclusive; everything that wasn't covered during the year was in the final exam."

☆ ☆ ☆

Brittle Fractures in Engineering Structures

D. J. Cook

During the development of steel as a structural material, engineers have been faced with the serious problem of the apparently unpredictable brittle fracture of low carbon steels. Most of the technical literature of the 1800's contains references to the brittle behaviour of steel, with particular reference being made to the brittleness of Bessemer steel. Early failures occurred in riveted structures (welding being a twentieth century development) and were invariably associated with low ambient temperatures and frequently started at punched rivet holes.

With the turn of the century, reports of serious fractures gradually became more frequent, and in the mid-forties when welded steel merchant ships suffered many casualties, the incidence of such failures reached a peak. The spate of research which followed confirmed a number of features of metal under load—these characteristics had in fact been established for many years, but had not been satisfactorily fitted into the context of the behaviour in service.

When steel fractures in a brittle manner the physical mechanism of failure is different from that associated with ductile behaviour. Steel can fail by either of two modes—shear or cleavage. Brittle behaviour is associated with a cleavage fracture mechanism and theoretically does not require nor involve plastic flow. Ductile failure requires plastic flow and is associated with shear failure which is a natural consequence of plastic flow.

The existence of two modes of fracture accounts for the change from ductile behaviour at high temperatures to the relatively brittle behaviour at low temperatures. At high temperatures the cleavage strength is high relative to the shear fracture strength, whereas at low temperatures the reverse is true.

Transition temperature ranges (i.e. the transition from "ductile" to "brittle" behaviour) are determined by Notch bar tests. These tests are conducted at various temperatures to determine the temperature range over which an appreciable change takes place in some measured value such as energy absorption, ductility or fracture appearance. This change frequently occurs rather abruptly; for example, the energy absorbed in failure may drop abruptly from a high value to a much lower one within a narrow temperature range. The width of the transition range varies with the test conditions, the specimen geometry, the manufacturing practice and the chemical composition of the steel.

Although brittle behaviour is not uniquely associated with welded construction service failures are more likely to occur in welded structures since there are no structural discontinuities such as riveted joints, which can effectively interrupt the progress of a brittle crack. Moreover defective welds have often provided notches and hence points of stress concentration to initiate a fracture. Welding is also responsible for a further complication in that it introduces residual stresses. These stresses generally approach the yield strength of the metal in magnitude and arise because of temperature gradients created by the welding operation. The existence of residual stresses is well established, but the effect of such stresses on the behaviour of welded structures is still a matter of debate. However there have been many fractures in unloaded components and in full-scale structures that were caused by residual stresses or by a combination of residual and thermal stresses.

Actual service failures are usually a result of a combination of circumstances and failure cannot generally be attributed to any one cause. The following examples of brittle failure will illustrate this.

During the period 1938-40 three welded Vierendeel truss bridges spanning the Albert Canal in Belgium failed. Each failure occurred when the ambient temperature was around 7°F. Subsequent inspection of all failures indicated that all fractures were cleavage originating at welded junctions. "Mechanical tests on steel from the bridges were apparently satisfactory, except perhaps for somewhat low Izod and

FIELD NOTES from CP

OCT.-NOV., 1959

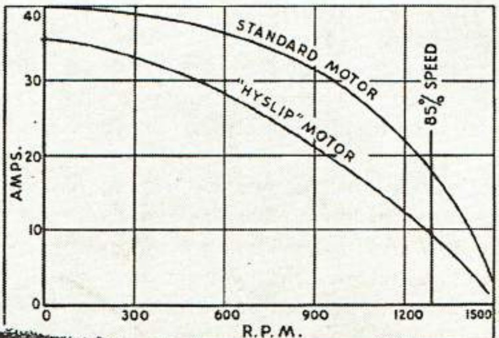
ACTUAL CASES OF ELECTRIC MOTOR USERS' TROUBLES SOLVED BY CROMPTON PARKINSON SERVICE ENGINEERS

The "Hyslip" helps out in Press Problem

The call came from a manufacturer who had just installed several stamping presses to perform an operation essential to production. The standard C.P. 5 h.p. squirrel cage motors supplied with the presses were overheating . . . and the consequences of even a partial loss of production would be serious.

Our service engineer quickly established that the motors were overheating because the presses were employed on a duty in excess of the designed capacity. A stamping press being a machine dependent upon the kinetic (or stored) energy of its flywheel to carry it through the duty stroke without detrimental loss of speed, the obvious requirement in this case was heavier presses. **But the manufacturer had to keep going with the machines on hand, or suffer severely.**

Fortunately, we could, and did, help out . . . by supplying our C.P. "Hyslip" squirrel cage motors to replace the stan



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Charpy values (Notch bar tests)".

A further failure occurred in a welded girder bridge in 1951. The Duplessis Bridge in Quebec, Canada, was only 27 months old when two fractures were found in the girders (the girders were 32 feet apart and were made of continuous welded plates 12 foot deep at the piers and 8 foot deep at midspan). Both cracks had originated in the top flange plates and had extended part of the way across the girder. The cracks apparently started in the welds. "Paint found in the cracks indicated that the initial fractures had existed before the girders had been erected. Repairs were made by riveting, and all tension joints were thereafter reinforced with riveted plates."

Sudden collapse of the bridge occurred almost a year after repairs had been made. The following investigation indicated the steel used was unsuitable. Alloy content was variable, yield strengths varied between 27,8000 p.s.i. and 57,800 p.s.i. and Notch tests (Charpy) showed only 3 to 6 ft. lb. @ 100°F. Brittle fracture had initiated at defective welds.

In 1962 the failure occurred of the King Street Bridge in Melbourne. On July 10th, a low loader weighing with load, 35 tons, drove over a span that suddenly collapsed—sagging a distance of approximately one foot. Examination found that the fractures all started from the welds at the ends of the cover plates (Tapered cover plates were completely welded to the flange of the girders by fillet welds running the entire length of each side of the cover plates). "In every case fracture had initiated at the toe of the transverse weld at the end detail of the cover plate and extended completely through the lower flange up the web, and in some cases through the upper flange. All fractures were typical of failure by "brittle failure" originating from toe cracks in the parent metal of the flanges at the transverse fillet welds."

The subsequent Royal Commission into the failure of the bridge found that the steel was too variable in quality, some of it was notch brittle and because of the high carbon, manganese and chromium content, much of it was difficult to weld. However commenting on the welding, the Commision stated that although the quality of the steel increased the difficulty of producing crack-free welds, the cracking found was so generalised that the fabrication techniques were largely responsible for them.

The examples of brittle failure mentioned have been in welded girder and truss bridges. Service failures have obviously occurred in other structures (See References 1 and 2).

No doubt brittle behaviour of steel will be a cause of anxiety to engineers for sometime to come. However with the recent accumulation of knowledge the uncertainty that has long obscured the brittle fracture problem has been lifted. Improvements in steel, in design, in welding and workmanship have gone far to reduce disastrous failures. Perhaps such failures can never be completely eliminated—"rarely have failures started in regions where there have been no obvious defects in design or workmanship."

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☆ ☆ ☆

BRUSH UP YOUR MATHEMATICS

If a rope hung over a pulley, having a weight at one end and a monkey at the other, the same weight as the weight, and the rope weighs 4 ounces for each foot, and the age of the monkey and the monkey's mother is together 4 years, and the weight of the monkey is as many pounds as the monkey's mother is years old, and the monkey's mother is twice as old as the monkey was, when the monkey's mother was half as old as the monkey will be when the monkey is three times as old as the monkey's mother was, when the monkey's mother was three times as old as the monkey.

And the weight of the weight and the weight of the rope is half as much again as the difference between the weight of the weight, and the weight of the weight and the weight of the monkey.

What was the length of the rope?

THE CHANGING FACE

The place of spectacular architecture in academic achievement is not clearly apparent. Why then has our university flourished recently in such a concrete manner? What is the argument against providing the equivalent floor space by way of Nissen huts?

It would not be right to attempt the design of a library with such purely functional aims in mind. Everyone's conception of a library is something more than a storage place for books and a study area. The place should have atmosphere. But the new library is strictly something to surround Encyclopaedia Brittanica.

The man who said "build yourself pillars of wisdom" didn't intend such a literal interpretation.

It seems those who govern have come to realise the worth of the State's University in an unfortunate way. They try to please industrialists and foreign investors not only with supplies of engineers and scientists, but with the reassurance of some tangible evidence of culture. In fact, every prosperous community must have its cultural edifice.

Of course, studying reclined in padded chair, gazing at Winthrop Hall, one has to admit that the new library doesn't altogether seem a bad thing. But it is asumptuous way of doing something which after all has little connection with physical situation. Surely we seek to achieve a state of mind. The buildings of the university are as remote from the actual achievement as the paper on which our B.E. is written.

The measurable worth of this institution is becoming increasingly apparent to those with no capacity for academic appraisal. We wish to satisfy not only those interested in our thinking ability, but those conscious of the position we purport to hold in society. We seem to be striving to acquire a home which adequately reinforces the status image we wish to project of ourselves.

J.A.B.

HEY FRED!

Hey Fred! A funny thing happened to me on the way to the dinner. I'd just got onto the freeway when I saw this girl, waving me to stop. Attractive young thing. Bikinis.

What dinner?

Coming to that. How's every little thing, says I. Oh, woe is me, says she. No petrol, no money. Please help, kind sir! I introduce myself, syphon gallon of petrol from Morris to Jag. Hers is Virginia. She doesn't know cars from nothin', but she's glad I'm so kind.

Funny kind, Ha, Ha!

Do you want to hear or not? Off she goes and off I goes. Half a mile later, there she is again. It's you is it? She smiles. Flat tyre. Please help, lovely man. How to refuse? Smile. Best suit covered in dirt, hands filthy. You must be cold in that. She explains—cold hands, warm heart, and thanks from bottom of it. Disappears into twilight with cloud of smoke.

Was it the Engineers' Dinner?

Name any other! Half mile later, there's the Jag again, young thing beside it. Smoke from bonnet. Motor fell out, she says, hands getting colder every minute. Just lives half mile on. Perhaps give her lift, and wash my hands—please? So later I'm clean. Mayhap wouldst come to a dinner with me? After all you did, how to refuse? Half an hour, we're there.

In the bikini?

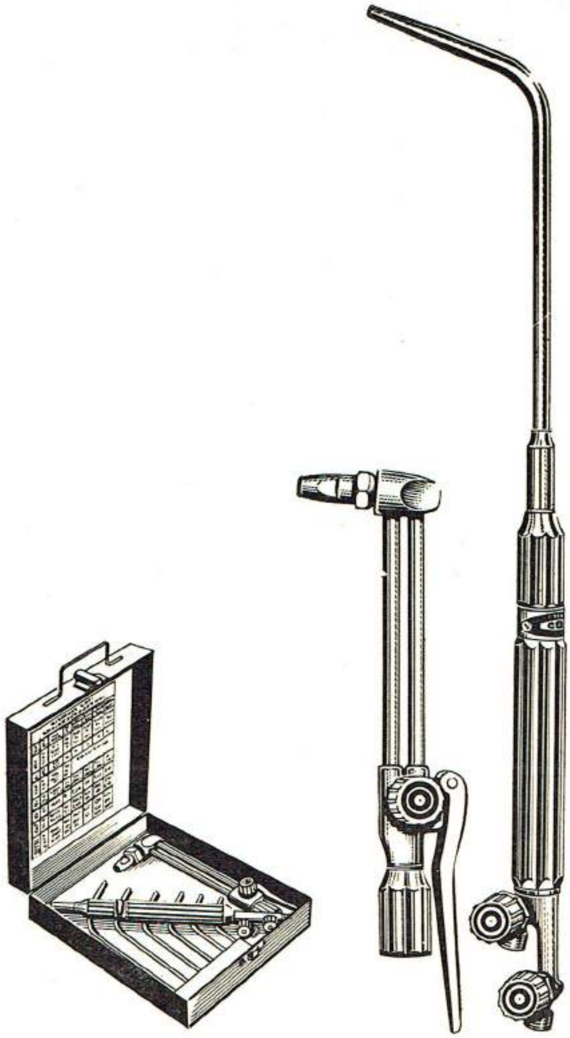
You nit! Georgeous green gown. Marvellous show! Plenty wine, dine and dance. Big rock band. So there we are, half blotto. Takesh me home! Zoom—! No shooner shaid than done. Coffee, dear? Perhapsh I better. You lie here, I'll bring shome. Back she comes, holding coffee in soft, tender, cold hands. Warm heart, she says, pouring coffee into me. Teeth stop itching. She turns on soft music, turns down light. Is this a proposal or a proposition?

A proposition is the wrong thing to end the sentence with! Ha, ha!

Krang! Laugh at your own jokes, see if I care. Just for that I'll say no more. You'll have to go to this year's dinner to hear the rest, if they let me speak.

No one's been able to stop you yet.
If you weren't so small, I'd belt you!
If you weren't so big, I'd let you!

BRUTUS.



F-1

by D. J. Craze

This is the designation given to the largest conventional liquid propellant rocket engine outside the Soviet Union. Rocketdyne Division of North American Aviation is developing the engine for N.A.S.A., to be used in the Saturn 5 booster, key element in the United States' Manned Lunar Landing programme. A description of the 1.5 million lb. thrust engine and an outline of its operation follows.

The Engine

The complete unit, consisting basically of a tubular walled thrust chamber, a direct drive turbopump with gas generator and their controls, weighs approximately 17,000 lbs.

The thrust chamber assembly is made up of a tubular wall incorporating regenerative cooling in both combustion and expansion chambers, a double inlet oxidiser dome, four integral fuel valves and a flat face injector. The expansion area ratio is 10:1. The approximate dimensions of the thrust chamber are 40 in. chamber diameter, 10 ft. nozzle exit diameter and 12 ft. length. The chamber is designed for the attachment of segmented, uncooled nozzle extensions, enabling an area ratio of up to 16.1 to be obtained, depending on operational requirements.

For simplicity and reliability, the turbopump is a direct drive unit. The fuel and oxidiser pumps are driven by a velocity compounded turbine, which at rated conditions develops approximately 60,000 horsepower. The assembly is about 4 ft. in diameter, 5 ft. long and weighs nearly 2,500 lb.

The oxidiser is supplied to the pump through a simple inlet, in line with the main shaft and is discharged radially through dual outlets. The dual outlet design balances centrifugal forces and minimises the pump diameter. The fuel pump has dual inlets and outlets for balanced load distribution and minimum size. Fuel and oxidiser lubricate their respective pump bearings.

The partially spherical gas generator is approximately 10 inches in diameter and burns about 2 per cent of the total propellants consumed in the engine. The gas generator design makes use of a double wall combustion chamber through which the fuel flows to cool the body, regeneratively. This feature eliminates a hot outer surface which could ignite leaking propellant, and also reduces heat radiation to adjacent components.

The main controls are: four fuel valves, integral to the thrust chamber assembly; two oxidiser valves mounted on the thrust chamber dome; a gas generator valve; a fuel and oxidiser flow regulator for the gas generator; and a four way solenoid valve. This solenoid valve is one of the only two components in the engine requiring an electrical supply, the other being the spark exciter for the gas generator. The fuel, oxidiser and gas generator valves use the fuel as their actuating medium. The oxidiser and fuel valves are of the poppet type which eliminates the turning moment associated with large butterfly and ball valves, simplify sealing problems, and minimises bulk.

The turbopump is mounted on the thrust chamber. All other components are either mounted on these two assemblies or are in the plumbing between them. The entire engine assembly is gimballed, thus only the low pressure ducting upstream of the turbopump is flexed. The high pressure fuel from the turbopump is used as the hydraulic actuating medium.

Operation

When the main fuel and oxidiser valves are opened, gas pressure in the tanks forces the propellants through 12 in. diameter fuel and 18 in. diameter oxidiser lines into the turbopump, from which a small quantity of each is bled to the gas generator. Ignition in the gas generator is accomplished by spark. The fuel rich exhaust produced drives the turbopump and is finally ejected, via a manifold surrounding the skirt into the main exhaust of the engine. This provides film cooling for the lower part of the thrust chamber.

From the oxidiser pump high pressure liquid oxygen (LOX) is fed through dual inlets to

the dome to ensure even distribution to the injector. It passes through feed holes to be finally injected through a pattern of 2,600 orifices into the combustion chamber in the form of fan sprays from sets of three metering holes.

The high pressure kerosine fuel (RP-1) is also fed through dual inlets to a chamber feed manifold. From here the fuel flows through alternate tubes, the length of the chamber (for cooling) and then to the collector manifold. The flow continues through four fuel valves, spaced at 90° around the chamber into an injector feed manifold. This distributes the fuel through 32 spokes into the injector, emerging from approximately 3,700 orifices in the injector plate.

The location of the valves downstream of the chamber tubes provides a greater degree of control in timing and sequencing the fuel for engine starting.

Mainstage ignition is accomplished using a hypergolic fluid, aluminium tri-ethyl, which is injected into the combustion chamber as the main propellant flow begins, causing spontaneous ignition. The initiation of this event occurs as the propellants are being fed from the turbopump; a small diaphragm is ruptured, releasing a pressurised cartridge of the auxiliary fluid.

Two tons of LOX and nearly one ton of RP-1 are burned in the combustion chamber per second. Translated to more colourful figures, the oxygen usage rate is equivalent to that of 60 million people in normal breathing, and in 3 seconds of mainstage operation, the F-I uses as much fuel as the average car uses in one year.

In operational use the F-I will be required to run at full thrust (1.5 m.lb) for 150 seconds. This has already been achieved many times.

At a distance of 1,400 ft. from a single F-I running at full thrust, the noise intensity approaches the threshhold of pain. The noise level will increase appreciably when five of these engines are running at once, as will be the case when their first flight test occurs in 1966 and the Saturn 5 rises on a 1,000 ft. long plume of flame.

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"German" Phrases for Guided Weapon Experts

Not intended as "Argument" material but surely good for a laugh is this list of "German" phrases forwarded to us from Woomera rocket range.

Guided Missile: Das Skientifiker Gessenwerker Firenkrakker.

Rocket Engine: Firenschpitter mit Smoken-und-Schnorten.

Liquid Rocket: Das Skwirten Jucenkind Firenschpitter.

Guidance System: Das Schteerenwerke.

Celestial Guidance: Das Schnibalische Schtargazen Peppenglasser mit Komputenrattacen Schteereenwerke.

Pre-set Guidance: Das senden Offen mit ein Pattenbacker und Fingeren Gekrossen Schteerenwerke.

Control System: Das Pullen-und-Schoven Werke.

Warhead: Das Loudenboomer.

Nuclear Warhead: Das Earengeschplitten Loudenboomer.

Hydrogen Warhead: Das Earengeschplitten Loudenboomer mit ein gross Holengraund und alles kaput.

Direct Hit: Das Bullzei mit Laudscheer.

Near Miss: Das Scheerbadlucken.

Misfire: Das Schweeren.

Infra-Red Homing: Das Schteerenwerke von Homensenden mit warmen Echschorsten.

Radar Homing: Das Schteerenwerke von Homensenden mit Blipblipecholisten.

Missile Engineer: Ein Kristolgazen Und Hittenmissen-gessenwerke Mann.

Launcher: Das Firenkrakker Upflingermaschine.

Catapult Launcher: Das Firenkrakker Pusspussupflingermaschine.

THE TELLUROMETER

An Application of Electronics to Surveying

by Peter Farr

It is interesting to note that developments in electrical engineering are, to a rapidly increasing degree, being applied in various fields of engineering and in other professions. The numerous applications of electronics in medicine developed over the past decade provide an example of this. An electronics application which may be of general interest is in surveying.

The distance between two points is the most frequent measurement required in surveying, and it should be capable of being found to a high degree of precision. In remote areas, difficult topographical or climatic conditions are frequently encountered by surveyors, and acceptable accuracy is not easily achieved by conventional methods. The introduction in 1957 of an instrument called the "Tellurometer" has produced a solution to this problem. The Tellurometer enables accurate surveys of large areas of difficult country to be made with appreciable savings in time and cost.

The instrument consists of a very high frequency (VHF) radio transmitter and receiver, plus auxiliary electronic equipment. To measure the distance between any two points separated by more than 500 feet but less than 20 miles, tripod mounted Tellurometers are set up facing each other. One instrument, called the master set, transmits a series of pulses modulated by a VHF carrier. The first pulse triggers a transistorised decade counter which registers the pulses from a crystal controlled pulse generator known as a "clock". The VHF signal is received and re-transmitted by the other (or "remote") set, and when received by the master set the "gate" controlling the counter is closed. Thus the number of clock pulses counted is proportional to the transmission time taken by the signal, and therefore upon the distance between the master and remote sets. It is a relatively simple matter to convert the count of clock pulses into distance if the pulse repetition frequency of the clock and the velocity of propagation of the radio wave are known.

In a distance of 20 miles, provided the country between the two ends of the line does not deflect the radio signals to a marked degree, an accuracy of $\pm$ 2 inches is obtainable despite the fact that the surveyors are out of sight of each other. Tellurometers have been used in snow, light rain, fog, dust and high wind without materially affecting accuracy of measurement. Conventional surveying methods are frequently impossible under such conditions.

A useful feature of the Tellurometer is a two-way radio telephone built into each set, enabling the surveyors to talk to each other merely by pressing a switch.

An illustration of the efficiency and accuracy of the equipment is the work carried out recently by B.H.P. in North-West Australia. Approximately 90 miles north-east of Onslow lies a huge deposit of iron ore spread out over 30 miles of rugged country along the course of the Robe River. Survey control points were required at one mile intervals to enable a wide coverage of the area to be made by follw-up methods in the form of plane table and stadia surveys. A network of points was built up and, when all the field observations had been reduced and compiled, the horizontal distances were found to have a closing error of 6 inches in 30 miles. A conservative estimate of the time required to achieve this order of accuracy by the ordinary methods of surveying would be about 12 months instead of the 7 weeks actually taken to locate the control points and carry out several reconnaissance surveys covering 70 miles.

The Tellurometer, already being made smaller, lighter in weight and more accurate, has proved a welcome and valuable aid to survey work in many parts of the world. Surveyors have been able to cover large areas of difficult country with accurate surveys and with significant savings in cost and time spent in field work.

Reference

Taylor, A. R.: "Exploration Surveys with a Tellurometer", B.H.P. Review, Vol. 40, No. 5, August, 1963.

VERTICAL TAKE-OFF

A Recent Development in Aviation

by Ian Jeffery

In military aviation greater emphasis is being placed on vertical take-off tactical and transport aircraft. Prototype vertical take-off fighters are now flying and supersonic vertical take-off intercontinental transport aircraft are now being considered as workable propositions.

At the present time there is great rivalry between the advocates of the different "systems" of endowing aircraft with vertical take-off and landing properties. The following is a short account of two of these systems which appear likely to be used in supersonic fighter aircraft. In the following discussion some abbreviations have been used. These are V.T.O.L., vertical take-off and landing; R.R., Rolls Royce; B.S., Bristol Siddeley; lb.st.th., lbs. static thrust.

The Vectored Thrust System

The Vectored Thrust system, championed by Bristol Siddley is based upon the B.S. Pegasus motor mounted in the Hawker 1127 Research Fighter. The motor is a front fan turbo fan incorporating some novel features. The compressor and fan rotate in opposite directions reducing "gyroscopic couple". The inboard portion of the fan acts as a supercharger for the compressor while the outboard section drives a large quantity of compressed air through ducts on each side of the engine. This air is then discharged through a pair of lateral nozzles. Furthermore, the hot gases exhausted at the rear of the firing chamber are passed through ducts leading to a similar pair of nozzles. These four nozzles can be swivelled to direct the jet efflux aft, or vertically downwards. By swivelling these nozzles the pilot of the 1127 can achieve both V.T.O.L. and conventional flight. Because of the low take-off and landing speed of the craft a special low speed control system is incorporated in the design. Air is "bled" from the compressor and fed to small controlled variable reaction jets located in the wing tips, nose and tail. Any tendency for the craft to yaw, pitch or roll is sensed by rate gyroscopes, and automatically signalled to an electro-hydraulic control system which operates hydraulic jacks to counter the tendency (manual control is also possible).

A method of reheat called plenum chamber burning is under development by Bristol Siddeley for this type of motor. It consists of burning additional fuel in the cool air ducted to the front pair of nozzles. Using plenum chamber burning additional thrust will be available for take-off, transonic acceleration and supersonic flight. Thus a smaller basic unit will achieve the specified performance with a reduction in weight and specific fuel consumption.

Pressure on the compressor due to the airflow apparently has led to the bypass ducts being replaced by Plenum chambers ("chambers usually fed from a ramming intake").

The Composite System

The composite system is based on lightweight motors mounted vertically and exhausting downwards to produce vertical take-off, coupled with a conventionally mounted motor for level flight. The system is championed by Rolls Royce and used by the French in the Dassault Balzac, a prototype of the Mirage IIIV vertical take-off fighter. The Balzac carries a conventional mounted B.S. Orpheus motor and eight downward facing Rolls Royce R.B. 108 motors. The jet system for stabilisation at low speeds has outlets under the nose, tail and wings. The Mirage IIIV will have a 19,840 lb.st.th. S.N.E.C.M.A. motor and eight K.R. R.B. 162, 4,400 lb.st.th. motors. The R.B. 162 is basically an enlarged R.B. 108 using lighter material and having a greater power weight ratio. The R.B. 108 weighs 269 lbs., and produces a thrust of 2,030 lbs.st.thr. with 11% air bleed for control purposes (its power weight ratio is 8). Due to extensive use of glass fibre reinforced plastic, the R.B. 162 has a power weight ratio of 16. The motor is an axial compressor encasing a single folded annular combustion chamber with

a single turbine stage. The compressor turbine shaft runs on only two bearings. The compressor appears to be made up of 6 stages, the first being of light alloy, while the others consist of plastic blades with aluminium alloy discs. The engine is started by the impingement of air on the turbine blades. As the air passes to the impingement jets it operates a piston in an oil cylinder which squirts a metered quantity of oil on to the bearings, this being the only oil system in the engine.

An added front (top) fan has been specified for a Nato design transport which would approximately double the take-off rating of the engine. (Portion of the air drawn in by the fan would bypass the motor and remix with the hot exhaust just aft of the turbine, thus increasing substantially the mass of the exhausted gas). In multiple lift-jet application it is planned to insert engines of this type in the aircraft rather like light bulbs (everything connects automatically on insertion). Rolls Royce have achieved a thrust response rate to throttle movement of 1/10 second (approx.) resulting in good direct manual control of height during take-off and landing.

Advantages and Disadvantages of the "Systems"

In the Vectored Thrust system, a large motor is needed to produce the required lift for take-off. This is advantageous for high altitude, high speed cruising. However for low level cruising the motor must be throttled well back and fuel economy is less satisfactory. This factor appears likely to be overcome by a smaller basic unit using plenum chamber burning. The advantage of hovering propulsion efficiency of the Vectored Thrust craft is lost as range increases and the cruising fuel consumption becomes important. The Vectored Thrust system has the advantage of conventional installation, and the fact that the entire thrust is available for vertical take-off.

In the small downward exhausting jets of the Composite system, fuel consumption is fairly high, the emphasis of design being on low engine weight and high power weight ratio. The Composite system has the disadvantage of having a number of motors and unconventional installation. It has however an added safety factor in that the pilot can land the aircraft even if the main motor fails.

Both systems have disadvantages when used to power large aircraft (e.g. transports of the future). The larger the motor of the Composite system, the lower its thrust response to throttle movement, a disadvantage during take-off and landing. These motors will also suffer thrust loss if they are designed to supply high pressure control jets. In large aircraft considerable complication and an increase in weight will be caused by the pipes and linkages necessary for this pressure jet control at low speeds.

The Future

At present there are a number of aircraft on the drawing board, military and civil craft of the future which will use either, or a combination of these systems. Hawker Siddeley has received a N.A.T.O. contract to build a short take-off and landing craft powered by four B.S. Pegasus motors. This will become V.T.O.L. by the addition of two large packs on the wings, outboard of the main engines, each containing eight downward exhausting jets. Fokker (Netherlands) in conjunction with Republic Aircraft (U.S.A.) intend to build a transport using B.S. Pegasus motors.

In both civil and military aviation it now seems certain that the V.T.O.L. aircraft is the craft of the future. Both the "Vectored Thrust" System and the "Composite" System appear to be here to stay. The Hawker 1154 (a development of the 1127) has been named as the successor to the Hawker Hunter Fighter and it may be the successor to the naval "Sea Vixen". The French Government has strongly supported the Mirage IIIV, and these two craft have been selected by N.A.T.O. to meet the Nato Basic Military Requirement 3 for a strike fighter with vertical take-off and landing capacity.

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Lectures are like steers' horns — a point here, a point there, and a lot of bull in between.

Woman — or what a man marries

BY WOMAN HATER

They have the usual form—torso, arms, legs and a head which is only used to keep cosmetic factories in business. To get on in the world they only have to have enough intellect to make eyes at men, put lipstick and eyebrow pencil on straight and boil water.

There are three general classes: (1) Crows; (2) Widows; (3) Wives. Crows are disguised blobs of humanity who hope they are lucky enough to catch a male and who paint themselves like Indians to do it. Widows are remnants with possibilities. Wives are of three types—prizes, surprises and consolation prizes.

Physiologists and scientists are still trying to ascertain why a strong, red-blooded intellectual thing like a man, should enjoy kissing a small, flabby scarlet-lipped dodo like a woman. If you flatter a woman you're a liar, if you don't, you're a bore. If you try to make love to her, you're fast, if you don't, you're cold-blooded. If you take her out and approve of her drinking and smoking, she swears you are leading her to the devil; if you don't approve of her drinking and smoking she tells you to get back to your pulpit and preach to the people who will believe you. If you talk about anything higher than sixth-grade standard she looks upon you as a man from Mars, and if you come down to her standard to please her, she wonders if you have a brain. If you make an impression upon her sister she's jealous; if you don't she wonders why she goes with you. If you bring some of your mates home, she swears they are a bunch of drunkards, but if you don't like her friends, she moans because she has no social life.

Woman is merely a letter on the table, she comes along, gets shoved around, till finally some male picks her up and bags her.

"Student Engineer, 1963".

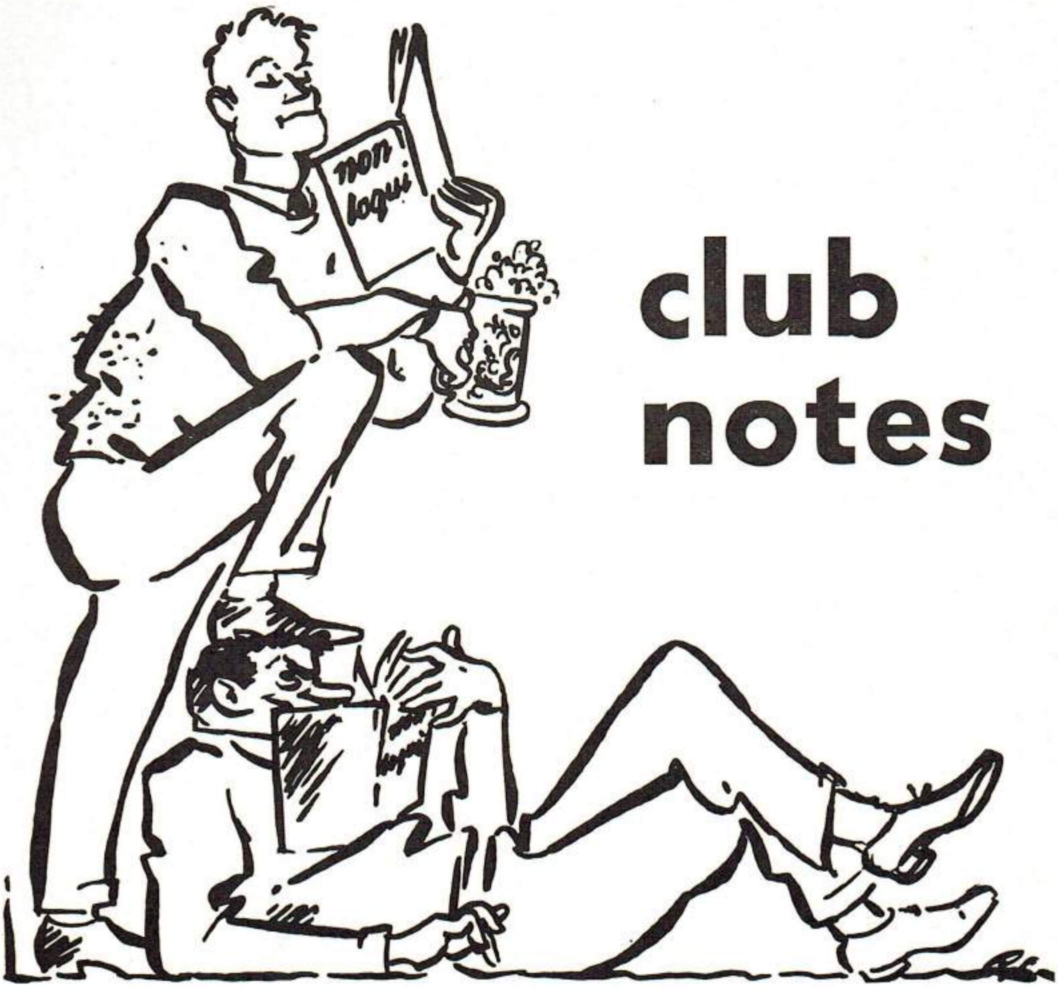
Ball floor show "Have you heard this one . . . .?"

At the helm.

Beatlemania at the Dinner.

Boatrace Night, Geehi.

Gledden Bus Bogged.



club notes

1963

FIRST YEAR

1963 was an active year for the U.E.C. and we feel that as first years we fully justified our membership.

The first social occasion of the year, put on by the club, was the Initiation, at which we were represented by well over eighty fellows. During the course of the night's ceremonies, amidst being plastered with paint, flour, dye, etc., we learnt two things directly concerned with U.E.C. membership. Firstly, who the bosses in the faculty were (or to say the same thing in an old fashioned sense—who wore the pants and who didn't), and secondly that lawyers make first class ponding material. At this stage we must add that from a faculty point of view, we finished the evening on a bright note by ponding several lawyers after Freshers' Ball.

The next significant act in our first year case history was the election of S. M. Yip as year Rep. on the U.E.C. Committee. In Yip we found a great leader, his qualities being recognised immediately when he led a successful ponding campaign against a 4th year lawyer who organised a tomato-throwing riot against a senior Engineering student.

We represented ourselves in Prosh with a "Ban the Something or Other" type of float, and an abundance of voice and unbecoming behaviour. We didn't win the prize for the best float, but this was explainable as the judge wasn't an Engineer and was thus naturally biased. Also no confidences would be entered into, particularly as regards date of entry.

The Bucks' Dinner was a great show and for first year students, U.E.C. interest ran high with a large attendance and plenty of spirit—especially at the all night show afterwards. At the dinner, Yip excelled by making a fine speech which, along with numerous beers, was well received by all.

During the Engineering Exhibition the club benefited greatly from our solid support in that we carried billboards around Perth for three days, and showed exceptional skill as parking attendants and ticket sellers.

Since we didn't win the Goyder Cup its mention must be brief; it would be sufficient to say that we were provided with a good sporting interest paralleled only by our weekly golf matches which ran undisrupted throughout the year.

The Friday night social gatherings in the Common Room were greatly appreciated by those who attended and are recommended as a must for everyone in Second Year.

The Dinner and the Ball both received First Year representation, and like all other U.E.C. functions, both were extremely successful and enjoyable for all present.

The next main item on the year's agenda, was the annual examinations, and it is with re-

gret that we add that this was the only time during the year that Yip failed us. In point of fact he failed everyone, but in so doing equipped himself admirably to lead the passing out parade. All remaining wish to express their deepest sympathy to Yip and Co., and hope that 1964 is as slack a year for them as 1963.

However the sorrow of parting with such friends was lessened around the keg during the last U.E.C. function of the year—the River Trip which formed a first class evening with which to wind up the year—and these notes.

SECOND YEAR

It could hardly be said that the '63 2nd year students were a group of abnormally intellectual individuals. In fact, only fifty per cent. of us won the final round with the examiners. It may be a little late to point this out, but I seriously doubt whether the examiners realise that they are rapidly and efficiently cutting their own throats. To my mind it is obvious that at the present rate at which we are weeded out, there will be few or none of us who gain 5th year, and hence there will not be the need for a lecturing staff as large as it is now. I trust that these few words will not fall on deaf ears, and that we can expect a more sensible and lenient attitude in the future. I would remind the academic staff that primarily it is *your* welfare we are considering, not our own.

We must offer our sympathy to our colleagues of '63 who fell victim to the wrath of the examiners. Strictly speaking, there were many of you we could not term as colleagues, your appearances being somewhat sparse. To those who are repeating we wish you luck, but also hope that we never have the misfortune to be forced to rejoin you. To the remainder, we wish you luck in your new careers.

It is pleasing to note that the dashing vogue set by the bearded Prof. has at last caught on. On returning to Uni. this year, one was immediately struck by the increased number of hairy faces. It must be very gratifying to the Prof.

In a more serious vein, I think it is opportune to point out that there has been a serious and obvious lack of enthusiasm by our year towards Engineers' Club activities. The Club is run for your benefit, using your money. Even if only to safeguard your annual investment, each of us should take an active interest in the Club's activities. While no-one could say that Uni. life should be all play, neither could anyone claim that it should be all work. So why not spend some of your idle hours either helping to run the Club, or taking advantage of some of the facilities and enjoyments that a hard-working few provide for you? Surely, this is the least compliment you can pay to those who are doing the work.

THIRD YEAR

Faced with the reality of the split into Mechanical, Civil and Electrical groups, the men of third year vowed never to drift apart. The pact was sealed with the spiking of a keg on the first night of term. It was a constant source of joy and gratification that so few of the solid lads had been felled by the examiners. So with a fine complement aboard we set sail through the amber sea of third year.

Line honours must surely go to Mol, who actually conned at the Freshers' Ball dressed in his boiler suit and looking more colourful than any freshman (too bad he never remembered it). The night of the Bucks' Dinner was a triumph for the Electricals. The show afterwards at Phil's really swam, and Harry's effort is still discussed in much revered tones. Let the Mechanicals take credit for a fine performance at the second term social. Simon even completed the night trying to tell an irate policeman in Barrack Street that seven engineers in his small car was a world record. The Civils however still claim star billing for that party, after which Tub was evicted, at four in the morning, from his 'bed' on some Dalkeith verandah. ("It was raining when I fell asleep," he claims).

The whole year seemed to be full of evenings such as these: dear memories to be treasured. After the exams several members spent a pleasant evening crawling around Rotto, by way of a finale.

Social activities did not, of course, fill all spare time. The year may boast of some fine sporting achievements. Max and Bill showed real style and determination in the Aquatics. Several men became very proficient at Squash, whilst working up thirsts. Despite their respectively curious structures, Dave and Kells both played commendable football. Coops was even persuaded into a bath tub; he was heard to remark: "Thank heavens it is only once a year."

To fill in the odd remaining daylight hours, there were lectures and lab. classes to be attended: John even went to maths. prac. (one up for the Electricals). To be quite candid, there were several occasions when everyone was hard at work. Civils, complete with theodolite, could often be seen busily taking stadia readings on prominent fresherettes; the Electricals industriously blowing fuses, noses, meters, motors and transistors; and the Mechanicals feverishly trying to start motors with no fuel and/or pistons in them.

The title "Lecturer of the Year", after much deliberation, was lavished on Dr. Phillips. We mourn his loss and his classic opening and closing questions: "And what were we doing last

time?", "When do I see you next?", will never be forgotten. The Civils still cherish the memory of Mr. Reynolds' lectures—"it is all nonsense anyway." The Electricals, however, save pride of place in their hearts for Dr. Bundell, who once replied: "That's no cross, it's the —— end of a —— arrow."

All in all, it was a very satisfying year, and a glance through the exam results indicates that most of us chose the right moment to lay down the jug and glasses and take up the pen and slide rule—thank heavens!

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FOURTH YEAR
Civil

Whatever disappointment may be occasioned to those avid seekers after publicity, who year after year attempt to achieve celebrity in this column, it will no doubt be mitigated by the knowledge that the column this year has fallen to the lot of a degenerate who, after successfully putting off the Editor for months, has finally been cornered. So with one hand to the glass, your representative hopes to conjure up those little glimpses of ourselves that we so love to see in print.

In a more serious vein, 4th year civil started the year with the same numbers as in third year, having lost the genial Chin, C. Y. and gained Ian Wells from Duntroon. Faced with the prospect of only two terms, students and lecturers alike faced the new-look course with a certain amount of apprehension. When lectures commenced most lecturers commented that this year we were doing twice (or was it three times) the amount of work in half the time as previous years. Mr. Sacks, getting into the swing of things, specialised in three hour marathons during which he pursued Surv. II studs. from Hump to Llandadno and back again. His afternoon lectures, as a result, were punctuated with bouts of footing the leather. Mr. Reynolds lectured in his usual inimitable style . . . . Zeno performed a few tricks in the concrete lab. causing Mr. R. to make many a caustic comment, i.e. "That's a heap of wet stones not concrete." (Zeno was well supported in his concrete career by a solid group of experts—Tony, Loui and . . . need I say more). Doctor Silvester sped through his lectures showing that he had lost none of his third year dash. In fact, he lectured with such rapidity that we had the exam before second term vac. Then

having set a supp. he left the campus for places where he wouldn't be bothered by students. Mr. Clegg remained a friend of the students even after the Soils exam. The results bore out this friendship, few, if any, crashing.

While on the subject of exams, mention must be made of the fact that everyone passed. Mervyn got the usual, Tony got the usual, and Firey Fred Fawcett shocked his critics. Mention must also be made of the stunts Ian worked on at the Ball. His few tricks netted nine falls—after the last he was taken home.

The eight Civils who made the Gledden Tour proved to be a varied bunch. The reason for the behaviour of some individuals became logical when they returned home. Ken, Mike and Bruno (in that order) soon became starters for the Marital Stakes. At this stage Mike seems to be a length ahead, but rumour has it that another Civil is about to make the plunge so the final placings are still in doubt. The Tour brought many new conquests for Zeno, highlighted, some say, by an evening with a certain wench in Canberra.

Maintaining his standard Zeno conned well on the train coming back. Complete with boots, spurs, dogs and horses this babe beguiled Zeno so completely that she was even seen smoking his pipe. Mervyn won a heart in Sydney to such an extent that she sent him a combination nut cracker, bottle opener, corkscrew and can-opener for Christmas. Obviously she got the wrong impression.

Anyone else who deserves an individual mention would be unbearable if he got it, so we'll leave it at that.

Note: This paper is neither soluble, safe nor soft.

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FOURTH YEAR
Electrical

On the 11th of March, ten students aspiring to greater academic achievement congregated in a small back room of the engineering school and there at precisely 9 a.m. received the first of a series of signals from the very depths of space. The group split into two factions and the ensuing five months were spent investigating and cataloguing the emissions.

The first signal received emanated from Alpha Ursae Majoris and upon deciphering was found to pertain to a random motion of abstract particles and resulted in the conclusion, well summed up in the Heisenberg uncertainty principle, that nothing could be said about anything; which rather put a hole in the whole message.

Zeta Ursae Minoris . . . Strange and indecipherable signals received which appeared to convey some theory of non-existent. These were attenuated to -60 db after the first week as having no scientific value and being detrimental to mental stability.

Algol . . . Rather tricky signal continually changing wave-length and signal strength; showed a remarkable affinity for Taurus and all things connected with such. Notable interest was shown in these signals by one Neil Crosby who, in mid year, succeeded in reflecting the signal back to the origin without loss of information . . . much to the disgust of more conventional students. Also Geoff Baldock who attempted this feat but found himself on the wrong wave-length. Poor signal to noise ratio at most frequencies. One R. Smith has decided to continue investigations into this source.

Sirius . . . Little known source of interest to only three students. This clique usually buried itself in some dark recluse and information received was non-tenable to other than the few. The most remarkable case of student schizophrenia belongs to this group in the person of one student, who shall remain anonymous, whose thirst for knowledge frightened even the most industrious of the year. It is hoped that the enforced long vacation will effect a cure for this dreaded disease.

Orion . . . VHF and coded pulses investigated and found to be empirical with no relation to scientific deduction, being obtained by the time honoured method of calculating a

figure and then doubling it.

Beetlegoose . . . Good strength signals resembling those from Zeta Ursae Minoris but far more tangible. Excellent signal to noise ratio.

On the social side the Neptune Award for aquatic activities goes to J.A.B. for his effort at the first term bucks show. "Stayer of the year" went to G.W. for his truly Herculean effort. All were able to deceive the examiners and have moved on for the run down the home stretch.

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FOURTH YEAR
Mechanical

It is a noble professor and he faileth all but eight,
By thy wisdom proved or fate removed, is it yet too late?
Four years passed by noble toil, last one just begun,
Down towards the finish line the game is nearly won.

But we have done a hellish thing, apologies all round,
We've not introduced ourselves, haven't said a sound.
See that picture right above, those happy smiling men,
Was ne'er a group of any size half as good as them.

Langford, Whinnen, Brearly proud, to name but only three,
Zadnik, Filmer, Cullen too, the merry minstrellsy,
Sang and Williams but remain to make the famous eight,
Engineers through and through, nothing second rate.

The year began in early March, Thermo's and Dynamics,
Swotted, sweated, toiled and fretted, also in Mechanics.
Reports to write and problems too, whatever one believes,
Metals on the Thursday night, Coffee, then to Steve's.

But then the shock, the one we dread, the source of misery,
The odd one out, God forgive, engines in history.
There was passed a weary time and every gaze was void,
A weary time, a weary time and every face was bored.

August Vac., exams, and then east for all but one,
As bodies on the train were poured, Brearly missed the fun.
Away at last as engines throbbed, and o'er the desert sped,
Beer down the hatch was poured, then stagger off to bed.

'Twas Engineering dawn to dusk, but what of dusk to dawn,
Mr. Gledden with reverent thanks, if ere a saint was born.
Time sped on and days went by, sex we found was free,
Ol dream of joy was this indeed, with goodly company.

Right across the continent, South Aussie, Vic and Wales,
Moving quick and talking slick, covering our trails.

A week was spent in Sydney town, then on the move again,
A chartered bus departed thus with ill reputed fame.
Driven by a man possessed, a man of jokes untold,
With piercing wit and happy smile Toddy joined the fold.

He took us to the mountains high, he took us to the snow,
He took us up to Geehi and there the beer did flow.
Three teams of four selected for the long and tedious race,
We mech boys shot away at once, others losing face.

Four long hours we toiled thus, hard and fast and fair,
Though lesser men the distance failed tenacity was there.
The finish time was twelve at night and counting up the slate,
Gave forty as our winning score, the next got twenty-eight.

Up next morn each tongue was parched and every throat was slaked,
Eyes and heads like pulses beat and grins and smiles were faked.

With groans we stirred then all uprose to meet
the rising sun.
Then life returned and health discerned, penance had been done.

Southward through the snowy cliffs, southward aye we sped,
Then the home trip westward, the desert stretched ahead.
This weary group of happy men, I heard a sigh and groan,
A thousand passing memories, of girl friends and of home.

But now the year is sixty-four with fourth year left behind,
Let's stop to try and calculate, stop to think and find.
Let's stop to delve and estimate and ask with honesty,
What gain to us the year has brought in learning and maturity.

☆ ☆ ☆

FIFTH YEAR
Civil

The Ten Tall men gathered for the final year. Roy went to President of the UEC, Bob B. to President of Currie Hall. Brian got a guernsey as Debating Captain, Ffarro as film director and censor and Wal as Darts Captain. Stan, Bob W. and Laurie carried out all major construction at the Ball and Mirko supported West Perth. We think Jim Ryan is that tall solid type who sits at the back.

The line up of lecturers took shape. Two were visiting lecturers who attended regularly and some were regular lecturers who visited occasionally. The Prof. had "Stats" and proved conclusively from the morning paper that most people who had babies on any particular day were women. Mr. S. drew and designed—or we think that's right. When references were numerous, elegant and highly sophisticated the Doctor was in control. Mr. C. was famous for his marching music and speedy pracs. Illegal coupling up of water devices was explained and condemned by Mr. E. from ancient manuscripts which doubled as lecture notes. Others worthy of note were Mr. M. whom we occasionally sighted through the King Size Smoke Haze, and Mr. H. who frequently revised his

notes as new information came to hand.

Seminars showed varying qualities from Bob W's breathless rendition of ship designing to Mirko's 1½ hour Oscar winning portrayal of a man reading a costing code.

Laurie is believed to be building a fortress at Attadale from second-hand concrete cubes, cylinders and slabs, but Wal was the first to settle down. Bob Wark purchased a V-8 but parks it at home to avoid the traffic and rides his scooter to Uni. Brian proved that a well calibrated testing machine will fall apart long before the test specimen, and Roy found that a 12in. specimen is twice as long and heavy as the 6in. variety. Great things are expected of Big Jim, Bob B. and Bob W.—our honoured trio. Stan and Ffarro were engaged on projects of impressive importance while doubling as a welder and carrier respectively.

All things considered but mostly forgotten it was a great year to finish off a total of 60 years of University life.

☆ ☆ ☆

FIFTH YEAR
Electrical

Memories of a pleasant final year are likely to remain with us for a long time. It would be hard to forget.

Duncan's lectures (preparation — poor; knowledge of subject—doubtful; writing—indecipherable).

Howard's opening remark ("On the —end of fifth year it's a bit of a . . . .").

Harry's social life (very hectic in first term).

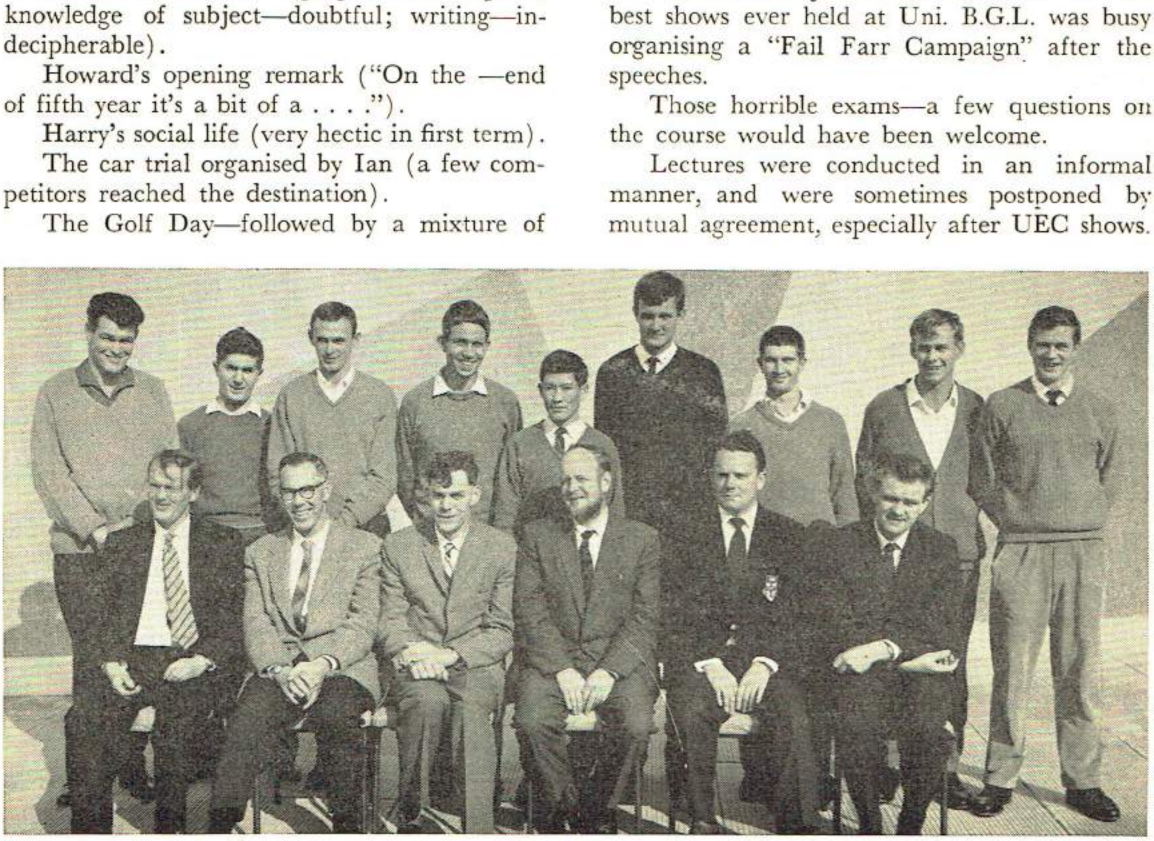
The car trial organised by Ian (a few competitors reached the destination).

The Golf Day—followed by a mixture of slops, arrows, ping-pong and anecdotes. The "Lecture of the Year" was given the following day by D.H.S.

The Golden Jubilee Dinner—one of the best shows ever held at Uni. B.G.L. was busy organising a "Fail Farr Campaign" after the speeches.

Those horrible exams—a few questions on the course would have been welcome.

Lectures were conducted in an informal manner, and were sometimes postponed by mutual agreement, especially after UEC shows.



Attendances were good because missing persons were conspicuous by their absence. We amazed Doc Fall by our ignorance and ridiculous answers to his simple questions—nevertheless he never despaired and three of the four distinctions were in his subject; thus patience is rewarded.

Just when we thought seminars had been abandoned, Prof. roused himself to action and organised some third term entertainment for the staff. Because of this bungle it was obvious that the guilding hand of K.W.T. was missing. In his absence, Prof. assumed the role of Chief Inquisitor. Howard showed good form, maintaining a stream of witty comments from the back corner. He and Ian could be Australia's secret weapon for the Tests in England this year.

Dunc organised a number of works visits, the most pleasant of which was a prac. class on the Swan including an inspection of the Raffles. Surprisingly no-one fell overboard, although Brian had trouble with a wandering jetty while mooring the boat. Other enjoyable events were the Golf Day and the party at Doc. Fall's home (I think Brian told a few stories on both occasions). Despite some casualties, including the odd broken wrist, the Ball was a swinging show. Alan was in great form, benevolently distributing high octane "Rum and Cokes" to various lecturers. Few people knew what the decorations represented until they read the newspaper next morning! Most considered that with wine, women and song everywhere, decorations were of much less significance than for a Winthrop Ball.

A good joint effort went into the Exhibition, with Ron and Wayne making outstanding contributions. The electrical section was definitely the highlight of the show. The public had their first viewing of a "Radar Trap", a "Microwave Thief Detector" and H. F. Cooking. Pred's "Passion Meter" provided a chance for greasers to show their virility. We are especially grateful to Dr. Leary and Dr. Steven for their interest and assistance with the Exhibition.

Wayne renounced the bachelor life early in the year, followed later by Harry (have joey's while you are young!) and Ian. This left only three single men. Alan (quite content with the status-quo), Warren (shouldn't be long) and Peter Farr (Library book philosophy). During the year Ron became a father, and a second child arrived for Rich and his wife on the morning of Zig's exam. (Stop Press: Warren has been hooked at last).

The Honours candidates struggled against supreme odds, particularly their own ignorance, and all came home with Seconds. Typical experiences were: a gremlin became addicted to the liquid in Noel's electrolytic tank, Warren ruined a few dozen transistors, Harry finished his thesis about four weeks late and Peter Day handed his thesis in on the way to his wedding.

In brief:

Alan was well received by various girls on Wednesday nights—Thursday's prac. classes suffered. Harry was late once or twice.

Zig slowed down to a joke per millisecond. Due to overloading of the students, he was (fortunately) deprived of about a dozen lectures, but still managed to give 120 pages of notes.

A couple of co-mingles with the Physios and various functions associated with the Miss University Quest added variety to first term.

Confusion in tensors

"Best dressed lecturer"—Prof. and Dunc, equal first.

J.M.—"this graph goes around in ever decreasing circles like the famous bird."

Assessment of the lecturers—one distinction, one pass, rest fail.

"I want to be free"—cry of the cadets.

All graduated—some Magna Cum Laude, some Magna Cum Lager.

Table I		*Who's Paying Them Now*
Wayne	—	Aust. Pulp and Paper (Tas.).
Ron	—	Dept. of Supply (S.A.).
Peter Day	—	P.M.G.
Ian	—	S.E.C., A.E.I. (England).
Peter Farr	—	P.M.G.
Rich	—	Dept. of Supply (S.A.).
Alan	—	?
Warren	—	B.G.L.
Noel	—	P.M.G./Uni.
Harry	—	Karen/Controlled Data. Corp. (Melb.).

And so, after a pleasant five years in which we learned a little Electrical Engineering, we are let loose on an unsuspecting world.

FIFTH YEAR
Mechanical

Ants Beaumont

Completed the year with A, B and C. passes. Organised the Mechanical section of the Exhibition admirably. Remained unmarried or unengaged, but Judy is heartbroken. Designed gas turbine system to use Wundowie coke gas and showed skill in packing cans in Work Study prac. session. Working with B.H.P. at Port Kembla under their executive training scheme. Electrostatic Dust precipitators was the subject for his seminar.

John Corver

Passed with third class honours. Mrs. Corver kept John under control but allowed him to escort her to U.E.C. Ball and Dinner. Became a gyro expert with demonstrations of some amazing gadgets at the Exhibition—Dr. Hunka's notes only increased the mystery. Working in Sydney with the Dept. of Supply. Gave seminar on Friction in Bearings.

Ken Drynan

A successful Gledden Tour member, Ken worked and worried his way to two B's and a C. Ken drove the Rover gas turbine at the Exhibition—the noise must have affected him as he designed a noise suppressor for the staff research laboratory fan exhaust. Ken is still unmarried but is trying his hand in Canberra where he is working with the Department of Works. His was the first seminar, on Jet Noise Suppression.

Dick Elsey

Same passes as Ken. Organised the Exhibition and spent the proceeds rapidly with a new system of weekly estimations in presenting the Treasurer's Report to the Club Committee. Gave the shortest speech at the dinner. Working in the Perth Branch of the Department of Works. Unengaged and unmarried. Gave a seminar on Gas Turbine Regeneration.

Jit Hai Limb

Bobby achieved 2nd Class Honours after sniffing and clicking his way through the year. Bobby entered into Club activities well. Disappeared after exams and no trace has since been discovered. Was still unmarried at that stage. Gave seminar on Gear Trains to which Dr. Hunka responded.

Vic Johnson

Passed well after sleeping up the back most mornings. Kept constant on work being done by Ken at Currie Hall. Assisted with the Exhibition and featured at all the year's functions in between visits to Hay Street. Must be close to getting married. Working with Main Roads Department after designing a new road compacting vehicle. Expounded on Exhaust Manifolds in seminar.

Pete Kalmund

Passed after pulling out of Honours. Pete spent the year paying off his Zephyr and designing a suspension system. Gave a seminar on Hydrolastic suspensions. Was not seen at any Club functions. Working with the S.E.C. in Perth. Unmarried.

Rocko Katnich

Passed and is now flatting with Savs. and Ads. in Melbourne. Was engaged but is not now. Another gyro man from the Exhibition and a hot demonstrator. Designed a paper sorter and stackerer and presented a complicated seminar on Algae. Working in Melbourne with the Dept. of Army where his Kinematics fascinates them. A great Goyder Cup footballer.

Mick Skreiner

A brilliant academic with three A's and First Class Honours. Has moved to study for higher degrees at Sydney University. He will specialise in Kinematics under Dr. Jack Phillips who has become Associate Professor of Mechanical Engineering there. Gave a stirling seminar on Synthesis of Mechanisms. Organised printing, advertising, selling of programmes at Exhibition and made a profit. Addressed the Dinner with a few "um-chaps." Is still not married.

Akbar Syed

Passed well specialising in Fluid Mechanics. His interest in this field soon made him an expert relative to the rest and well worth consulting. Did his share of work in everything including his flat. His seminar on Aerofoil Face Design was a beauty. His report on the electrolytic tank was also good which must have pleased Mr. Cole. Still unmarried and has disappeared—rumoured somewhere over East.

Brian Watson

Second Class Honours with an A and two B's. Gave a well organised seminar on Pneumatic Controls, in fact everything he did was well organised. Much of the credit for this must go to his wife Ruth who was continually typing reports, etc. Working with Ford in Melbourne so bought a Falcon to drive over. The engine jumped its mounting on the Nullarbor. The only man to have a child in final year, Corve's had his in second year. Won the Institution O. F. Blakey Memorial Prize for a paper delivered on "What's become of the Gas Turbine Car."

STAFF

Did a great job with a class of moderate academic talent in passing us without Sups.—the prospect of having us upsetting their new set of lecture notes for the new course, forced them to do this. Three honoured us with their presence for a game of golf, and three for the Year photo.

Prof. Allen-Williams

Chaired the seminars with dignity and thoroughness. These seminars were the best medium for enterprise of the individual as seen by the papers written.

Dr. Hunka

Conducted lectures on dynamics and helped us to struggle with the struggle encountered when struggling. His holiday revision classes are a neat idea and recommended for other subjects.

Mr. Hemingway

Covered a lot of ground but left out much of the detail on air conditioning and refrigeration. Third term's Drawing and Design taught us to in the future have all revision done in 2nd Term to leave 3rd Term free for reports.

Dr. Phillips

Covered the Kinematics course the third time and still left us with a lot to think

about. Treated us to great day at Gibson's Lolly Factory, a meal and a few beers. It is certainly a sad loss to the University that he has left. His style of lecturing was uniquely inspiring and his interest in the students individually was unceasing. Dr. Jack gave us one of the very few opportunities we had of "Seeking Wisdom" in our five years of study.

Mr. Wager

Urged us through a big unit in Industrial Management. He made it interesting and an excellent introduction for the future. He joined us for golf and generally took both a scholastic and social interest in us.

Mr. Cole

Was once again unfortunately hampered by back trouble but thoroughly covered the interesting field of Fluid Mechanics. Is starting to push ahead installing Fluid Mech. laboratory equipment which will be a great help to our contemporaries.

Mr. Lutz

Delivered text book lectures. Particularly enjoyable was the series on Nuclear Engineering which was non-examinable. Mr. Lutz played golf with fervour. Always willing to help with lecture material, problems and others. Set a stiff examination paper but still passed us all.

Mr. Noyes

Enlightened lecturer with U.S.A. methods. A typical pose was squatting on the bench—we often wondered how he got there in amongst "Algebra parties" and smoke haze. A refreshing lecturer who really knows his stuff.

☆ ☆ ☆

The University of Western Australia
FACULTY OF ENGINEERING, 1964

Dean of the Faculty
Professor KEITH LEO COOPER

CIVIL ENGINEERING

Professor

K. L. COOPER, B.Sc. (W.A.), M.A., B.Sc. (Oxon.), M.I.C.E., M.I.E.Aust., F.Inst.W.Sc.

Senior Lecturers

J. R. ESPIE, B.E., M.I.E.Aust.
B. CLEGG, B.E., A.M.I.E.Aust.
G. HONDROS, B.E., Ph.D., M.A.S.C.E., A.M.I.E.Aust., M.A.C.I.
P. C. MASSEY, B.E., A.M.I.E.Aust., A.M.N.Z.I.E.
R. SILVESTER, B.A., B.E., Ph.D., A.M.I.C.E., M.I.E.Aust. (on leave).
B. G. SMITH, B.E., A.M.I.E.Aust.
G. C. REYNOLDS, M.E. (Adel.), A.M.I. Struct.E., A.M.I.E.Aust.
R. SACKS, B.Sc. (Surv.), F.R.I.C.S., L.S. (S.A.), M.I.L.S.
R. H. B. HEBBERT, B.A.Sc. (Br. Col.), M.Sc. (Queen's).

Lecturer

S. J. THOMAS, Dip.Mech.Eng.

Temporary Lecturer

N. H. G. MUELLER, B.E. (W. Aust.).

Temporary Senior Demonstrator

D. M. DEVENISH, G.R. Ae. S.

ELECTRICAL ENGINEERING

Professor

A. R. BILLINGS, B.Sc. (Eng.), Ph.D. (Lond.), A.M.I.E.E., S.M.I.E.E., M.I.E.Aust.

Reader

K. W. TAPLIN, B.E. (W. Aust.), M.I.E.E., M.I.E.Aust.

Senior Lecturers

J. H. BUNDELL, M.Sc. (Eng.) (Lond.), D.I.C., B.E., Ph.D. (W. Aust.), A.M.I.E.E., A.M.I.E.Aust. (on leave).
J. V. FALL, B.E. (W. Aust.), Ph.D. (Lond.), A.M.I.E.E., M.I.R.E.
B. G. LEARY, B.E. (N.S.W.), Ph.D. (Belf.), A.M.I.E.E.
J. MILLS, M.Eng.Sc., Ph.D. (W. Aust.), A.M.I.E.Aust.

Lecturers

D. H. STEVEN, B.Eng., Ph.D. (Sheff.).
Z. L. BUDRIKIS, B.Sc., B.E. (Syd.).

Temporary Lecturer

P. J. WOOD, B.Sc. (Eng.) (Brist.), Ph.D. (Lond.).

MECHANICAL ENGINEERING

Professor

D. F. J. ALLEN-WILLIAMS, M.A., Ph.D. (Cantab.), M.I.E.Aust., A.M.I.C.E., A.M.I. E.E. (on leave).

Reader

J. A. COLE, M.Sc. (Manc.), M.A.S.M.E., A.M.I.Mech.E.

Senior Lecturers

G. G. LUTZ, B.E. (W. Aust.), M.I.E.Aust. (Acting Head of the Department).
R. S. MINCHIN, B.E. (W. Aust.), A.M.I.E. Aust.
J. HUNKA, Dr.Ing (Lodz), Dipl.Ing. (Danzig), A.M.I.E. Aust.
E. W. HEMINGWAY, B.Sc. (Eng.) (Lond.), D.I.C., A.F.R.Ae.S., A.M.I.E.Aust., A.M.I. Mech.E.
J. G. WAGER, B.E. (W. Aust.), A.M.I.E. Aust.

Temporary Senior Lecturer

R. B. NOYES, B.S. (Mech.Eng.) (Purdue), M.S. (Mech.Eng.) (Oregon).

Lecturer

J. A. APPLEYARD, B.Sc. (Mech. Eng.) (Leeds), A.M.I.M.E.

Temporary Lecturer

J. R. BLAIR, B.Sc. (Eng.) (Edin.).

Visiting Lecturer

K. D. LLOYD, B.Met.E. (Melb.), A.M.I.E. Aust., M.I.Brit.F.

STUDENTS, 1963

FIRST YEAR:

Allen, K. G.
Allison, D. M.
Arnott, T. W.
Begent, M. T.
Bennett, P. G.
Binet, R. C. W.
Bremner, H. R.
Brookshank, B.
Cappeletti, J. C.
Carr, G. L.
Chan, C. Y.
Chan, M. K.
Chang, K. F.
Choate, B. A. G.
Clarkson, G. A. D.
Coronel, P. T.
Davies, E. V.
Dawson, M. W.
Delaney, W. T.
Dempster, M. L.
Dendroff, W. V.
Elphick, G.
Flintoff, W. T.
Fellinus, K.
Ford, J. E.
Frank, H. J.
Galanos, J.
Gardner, D. E.
Georgiou, J.
Gilbey, P. J.
Halleen, M. D.
Hambleton, D. V.
Harrington, R. A.
Harvey, D. R.
Heggart, R. C.
Hindge, J. F.
Ho, K. N.
Hoffman, L. S.
Hoile, R. A.
Hover, C. D.
Jarvis, C. J. E.
Jasinski, J. P.
Jeffreys, J. D.
Kikiros, G. C.
Kirkham, L. O.
Lee, R. W. K.
Lim, Job
Lim, Y. C.
Mac, N. B.
McCarthy, D. P.
McDonald, I. N.
McMath, T. W.
Mahony, G. D.
Marie, G. V.
Mirkva, J. F.
Morgan, R. C. E.
Muljanto, H. R. F.
Murphy, P. R.
Nathan, C. J.
Ng, F. W. H.
Ng, K. W.
Ng, V. M. W.
Oehlers, R. R.
Oliver, J. S.
O'Neill, A. F.
O'Sullivan, G. F.
Palmer, J. D.
Paterson, R. J.
Paton, I. H.
Popham, R. G.
Prisgrove, P. B.
Pritchard, E. D.
Robinson, K. L.
Robinson, W. P.
Roesenosoeksmadi,
Said, M. M.
Schon, E. T.
Schooneen, P. C.
Shier, F. W.
Slee, M. A.
Sleeman, J. A.
Spencer, J. R. V.
Stankovicius, R. G.
Stratton, R. C.
Thinkaran, N.
Thomas, A. D.
Tomlinson, J. M.
Ung, T. K.
Wallis, J. F.
Walters, K. J.
Warnock, J. S.
Waters, C. M.
Webb, D. J.
Weir, T. H.
Wilkie, J. McC.
Winslade, R. J.
Yeoh, S. H.
Yip, S. M.

SECOND YEAR:

Abbey, G. J.
Bagley, C. A.
Baranowski, N.
Bartley, J. W.
Beetles, D. V.
Campbell, K.
Chapman, G. C.
Cheng, H. P.
Clarke, B. A.
Clarke, D. V.
Coghlan, B. A.
Cole, R. J.
Corish, W. A.
Coxon, J. R.
Craze, D. J.
Dickerson, A. W.
Doornbusch, H. J.
Dufty, P. O.
Eastwood, T. R.
Faul, R. C.
Garrity, D. W.
Goh, T. K.
Harris, J. C.
Hewitt, B. E.
Higham, J. A.
Irvine, J. T.
James, G. J.
Jeffery, I.
Jensen, R. L.
Kelly, I. E.
Kerr, P. G. H.
Kish, C. N.
Koniuchiwskyj, E.
Kor, T. H.
Ladner, P. A.
Leung, C. S.
Lorimer, M. J.
McCullough, R. H.
McGill, K. J.
Mace, H. J.
Macey, D.
Malyniak, R.
Mercer, R. W.
Moore, K. M.
Mount, R. M.
Muller, J. G.
Nawawi, B. M.
Phillips, P. E.
Pritchard, R. G.
Richardson, H. W.
Ridzuan, B. H. M. S.
Rozlapa, A.
Rushton, D.
Smailes, R. J.
Somow, A.
Stewart, P. G.
Tan, K. L.
Tang, D. L. P.
Teh, J. K.
Temby, C. R.
Teoh, K. T.
Theunissen, R. F.
Thuy, P. N. D.
Veal, C. P.
Wildy, E. D.
Warokka, W.
Winters, K. J.
Wong, K. T.
Wong, P. Y.
Wu, N. W. T.

THIRD YEAR:

CIVIL

Bennett, M. G.
Chin, C. Y.
Clancy, M. F.
Duffy, W. J.
Jewell, R. J.
Mirkaldy, G. T.
Mitson, R. A.
Peraldini, J. M. P.
Pitman, F. S.
Smith, G. C.
Sweet, J. R.
Tan, K. L.
Vitali, R. J.

ELECTRICAL

Alderson, R.
Cole, T. W.
Collins, J. D.
Harvey, P. J.
Hullett, J. L.
Lazarus, E. D.
Molinari, B. P.
Southwood, W. A.
Tai, K. C.
Burden, H. J.
Drok, A. H.
Harris, L. R.
Paget, W. R.
Sung, Y. N.
Thoo, Y. W.
Townshend, J. M.
Walker, P. J.

MECHANICAL

Blackman, G. R.
Cooper, P. I.
Feldman, D. F.
Hudson, G. R.
Hueppauff, P.
Humphrey, N. E.
Kelly, J. H.
Musk, F. A.
Stanford, S. A.
Stevenson, C. S.
Vandeth, S. H.

FOURTH YEAR:

CIVIL

Bartley, K. M.
Chandashoto, S.
Chiang, S. P.
Chodorowski, T.
Cole, M. F.
Cook, D. J.
Fawcett, I. W.
Formentin, A. L.
Gobolos, Z.
Lee, C. L.
Middleton, A.
Mogridge, G. R.
Padley, J. W.
Paul, M. J.
Rinaldi, B. A.
Wark, K. R.
Wells, I. M.

ELECTRICAL

Baldock, G. C.
Biggins, J. A.
Crosby, N. R.
Gray, N. D.
Green, M. D.
Smith, R. H.
Tajul, A. B. N.
Tressider, T. N.
Whitehead, G. H.
Yeoh, K. K.

MECHANICAL

Brearley, J. E.
Cullen, H. G.
Filmer, J. E.
Langford, S. N.
Sang, N. H.
Whinnen, A. M.
Williams, M. J.
Zadnik, A.

FIFTH YEAR:

CIVIL

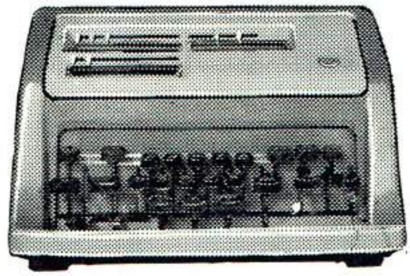
Brindley, R. F.
Dropulich, M. P.
Ellson, I. G.
Ffarrington, J. A.
Grainger, B. R.
Humphry, L. R.
Penberthy, R. A.
Ryan, J. E.
Wallwork, M. D.
Wark, R. J.

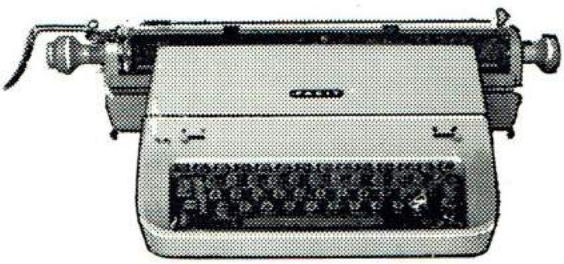
ELECTRICAL

Beaumont, W. F.
Campain, R. A.
Day, P. R. E.
Duckham, I. G.
Farr, P. J.
Hartley, R. H.
Low, N. H.
Smith, W. R.
Teede, N. F.
Wood, H. T.

MECHANICAL

Beaumont, A. J.
Corver, J. E.
Drynan, K. N.
Elsey, R. W.
Johnston, V. D.
Kalmund, P. V.
Katnich, R.
Lim, J. H.
Skreiner, M.
Syed, A.
Watson, B. W.





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